

connections, and, as noted above, since no standard connector exists, many connections are bare-wire type, which may not be reliable in a salt-water environment, or may be connected improperly, or become disconnected due to vibration and the like.

**[0052]** Even if connected, there is no guarantee the system will work. Extensive testing of DSC signals, as previously noted, has resulted in clogging of the DSC system, so boaters are not encouraged to test their system to insure it works properly. Moreover, boaters are encouraged to register their DSC-equipped vessels with the Coast Guard, such that a DSC emergency signal can be matched to a boating database to identify the vessel in distress. Most recreational boaters are unaware of this registration process, and few take advantage of it.

**[0053]** As a result, the DSC system suffers from the same implementation problems as many retrofit aircraft systems, such as collision avoidance (e.g., TCAS) or terrain sensing systems. These systems rely upon individual vehicle owners to install and maintain equipment to make the system operational. The system also will take time for such equipment to make its way through the existing vehicle inventory. Aircraft owners, may be required to install such equipment, and the safety concerns may compel many owners to install such equipment, even if not required to do so. However, unlike aircraft owners, most recreational boating owners are more lax about installation and maintenance of such equipment, and thus implementing and keeping installed DSC systems operational is more of a problem. A better solution would be to provide a vessel tracking system, which does not require recreational boaters to install and maintain new equipment, or one that allows for less complex equipment to be used, or to provide such a vessel tracking system as an adjunct to the DSC system.

**[0054]** In addition to the applications noted herein, multilateration and triangulation systems may be used for correlation with vibration, noise, audio, video, and other information. Other sources of information that may be correlated with aircraft or vehicle track information include audio and video data. Currently there are many systems that correlate this information used for environmental management including those implemented by Rannoch Corporation ([www.rannoch.com](http://www.rannoch.com)), Lochard ([www.lochard.com](http://www.lochard.com)), Bruel and Kjaer ([www.bksv.com](http://www.bksv.com)), BAE Systems and others, the respective websites thereof all being incorporated herein by reference. These systems may correlate the data in order to determine and identify which specific aircraft generated noise events or noise levels. Vibration monitoring may also be employed by these systems to track lower frequency events such as engine run-ups at airports. Although it has been discussed in the industry, airport noise monitoring systems have not generally employed methods to analyze the spectral content of aircraft noise for the purposes of classification (e.g., to distinguish between a jet or a turboprop).

**[0055]** In the example illustrated in FIG. 7 is from the BAE TAMIS™ product to compute the point of closest approach of an aircraft. PCA statistics include:

- [0056]** Slant distance,
- [0057]** Ground distance,
- [0058]** Aircraft position and altitude,
- [0059]** Date and time of the PCA,
- [0060]** Elevation angle from the PCA center point to the flight
- [0061]** Aircraft ground heading.

**[0062]** FIG. 8 illustrates a flight track that is selected from point of closest approach. FIGS. 9 and 10 illustrate a typical NOMS layout where the aircraft tracks are illustrated on a GIS map along with the locations of noise monitors. FIG. 10 illustrates the actual recorded noise level at each of the monitors on the GIS map. FIG. 11 illustrates a typical noise event for an aircraft as a Single Event Level or "SEL."

**[0063]** Primary radar is, of course, an active element, and if used as part of a surveillance configuration it is no longer covert. However, there are many opportunities in fielding passive systems to integrate feeds from existing radars to improve overall surveillance. Radar types range from long range systems covering several hundred miles to high frequency systems that cover only a few hundred meters, including:

**[0064]** Long range ASRS-4 built by Westinghouse/Northrop Grumman ([www.ngc.com](http://www.ngc.com))

**[0065]** Terminal ASR-8, 9, 11, 12 built by Raytheon ([www.raytheon.com](http://www.raytheon.com)) and Northrop Grumman

**[0066]** Surface Ku band radar by Cardion/Northrop Grumman

**[0067]** Surface X band radars including those built by Terma ([www.terma.com](http://www.terma.com)), Sensis ([www.sensis.com](http://www.sensis.com)), and Thales ([www.thalesatm.com](http://www.thalesatm.com))

**[0068]** Lower range, higher frequency radar such as the Tarsier™ by QinetiQ and the 77 GHz radar produced by Navtech ([www.nav-tech.com](http://www.nav-tech.com)).

**[0069]** Thus, it also remains a requirement in the art to fuse data from various surveillance sources, including primary and secondary radars, passive tracking systems, and the like, to create a robust and verified flight track or vehicle track, with redundant data inputs.

## SUMMARY OF THE INVENTION

**[0070]** The present invention provides a number of techniques to use multilateration and triangulation techniques for coastal defense, homeland security, search and rescue, in both coastal and mountainous terrain, as well as ADS-B back-up and validation.

**[0071]** While the Prior Art, such as the Schneider Patent discussed previously discloses limiting placement of the receivers for time difference of arrival measurement to three or more aircraft and/or spacecraft, in the present invention, a combination of receivers may be positioned on the ground, on aircraft, or marine vessels and buoys.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0072]** FIG. 1 illustrates a portable VERA-E passive sensor as set up in the field.

**[0073]** FIG. 2 is a cutaway view of the VERA-E sensor, illustrating multiple antennas.

**[0074]** FIG. 3 illustrates a VERA-E sensor as set up in the field, concealed by camouflage.

**[0075]** FIG. 4 illustrates a six-meter NOMAD buoy with solar panels and communications equipment.

**[0076]** FIG. 5 is a block diagram illustrating how the broadband aspect of the VERA-E system is achieved by using a series of interconnected antennas and receiver systems.

**[0077]** FIG. 6 illustrates an example of the range of available buoys.

**[0078]** FIG. 7 illustrates an example of the BAE TAMIS™ product to compute the point of closest approach of an aircraft.